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PROBABILITY ANALYSIS FOR PREDICTION OF ANNUAL MAXIMUM RAINFALL OF ONE TO SEVEN CONSECUTIVE DAYS FOR AMBEDKAR NAGAR UTTAR PRADESH

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ABSTRACT

The present study was conducted for probability analysis of previous 20 years (1993-2012) with the prime objective for the prediction of annual maximum rainfall of one to five consecutive days of Ambedker Nagar (Tanda). The observed values were computed by wei-bull's formula. The maximum rainfall values were estimated by proposed predicted models viz. Gumbel, Log Pearson Type III Log Normal and Gamma. The predicted and observed values were also established. The rainfall data has been in the above distributions and their corresponding rainfall events were estimated at 9.52, 23.81, 47.62 and 95.24 percent probabilities level. The goodness of fit models was tested by Chi-square formula proposed by Hogg and Tanis. The comparison between the measured and predicted maximum value of rainfall clearly shows that the developed model can be efficiently used for the prediction of rainfall. The statistical comparison by Chi-square test for goodness of fit clearly indicates that the Log normal distribution was found to be best model for prediction by Gumbel distribution shows very close relation to be observed rainfall for two consecutive day's annual maximum rainfall (mm).

***KEYWORDS:** Log Pearson Type III Log, prime objective & Chi-square test*

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INTRODUCTION

In India, after independence, due to population explosion and demand of more food production and irrigation development, 70% of the cultivated area of the country is under rain led agriculture. Average annual rainfall of the country is about 120 cm and 80 % of this occurs only in monsoon season. Indian economy has been traditionally direct or indirectly dependent on agriculture. Some parts of the country remains flooded every year, while there is no rainfall in other parts. India is an agrarian country as 70 percent of its population is engaged in farming. Due to favorable monsoon climate and-vast areas of the fertile cultivable land, the Indian economy has been traditionally dependent on agriculture. Some part of the country remains flooded every year, while there is no rainfall in other parts. Agriculture has an immense effect on our GDP (Gross Domestic Product) growth rate. As about 22 .1 percent of our GDP comes from agriculture.

Rainfall is one of the important hydrologic events, which plays an important role in many of agricultural and non-agricultural operations. The average rainfall of our country is 1190 mm per annum; it ranges from 350 to 2,000 mm. Most part of our country receives 80 per cent of the total annual rainfall during four months (June to September) of a year. Though the nature of the rainfall is erratic and varies with time and space, yet it is possible to predict return periods using various probability distribution functions (Upahayaya and Singh, 1998).

Detailed knowledge of rainfall pattern helps in planning crop calendar designing of different storage structures **(**Ray *et al*., 1987**)** to meet out irrigation requirement during drought period. The procedure for estimating frequently of occurrence of a hydrological event is known as frequency analysis. Analysis of consecutive days return periods is a basic tools for safe and economical planning and design of structural and non-structural measures, small and medium hydraulic structure such as small dams bridges culverts, spillways, check dam, ponds, irrigation mid drainage work in watershed management and command area development programmes and plant protection activities in a more scientific basis through the application of climatological information.

Efficient utilization of rainfall may increase the agricultural production many folds. Though the nature of rainfall is erratic and varies with time and space, yet it is possible to predict design rainfall fairly accurately for certain return periods using various probability distributions functions (Upadhyaya and Singh, 1998), Frequency analysis of rainfall data has been attempted for different places in India (Prakash and Rao, 1986; Aggrawal *et al.,* 1988**,** Bhatt *et al.,* 1996;. Upadhyaya and Singh, 1998; Mohanty *et al,* 1999; Rizvi *et al.,* 2001; Singh2001).

Rainfall modeling is an important area of hydrologic studies and is one in which research is still being actively carried out. Probability analysis can be used for prediction of occurrence of future events from available records of rainfall with the help of statistical methods (Kumar and Kumar, 1989). Based on theoretical probability distributions, it would be possible to forecast the rainfall of various magnitudes of different return periods. Analysis of consecutive days return period is the basic tools for safe and economic planning and design of structural and non-structural measures, small and medium hydraulic structure such as small dams , bridges, culverts, spillways, check dams, ponds , irrigation and drainage work in the watershed.

Frequency analysis of rainfall is an important tool for solving various water management problems and is used to assess the extent of crop failure due to deficiency or excess of rainfall. Probability analysis of annual maximum daily rainfall for different returns periods has been suggested for the design of small and medium hydraulic structure **(**Bhatt *et al*,1996).

MATERIALS AND METHODS

The methodology adopted for the probability of rainfall data of 20 years (1993-2012) to predict the 1 to 7 consecutive days annual maximum rainfall in Ambedker Nagar (Tanda). Rainfall data for Tanda block in Ambedkar Nagar was collected from (Department of Geography of Tanda).

Ambedker Nagar is located at 23°21'N 85°20'E 23.35°N 85.33°E. The total area covered by Ambedker Nagar municipal Area is about 111 square kilometers and the average elevation of the city is 133 m above mean sea level. The area surrounding Ambedker Nagar has been endowed with natural attractions and it is referred to as the “City of Waterfalls”. The most popular waterfalls are Ghaghra and Saryu rivers, which are all active perennially. The Ghaghra river and its tributaries constitute the local river system.The city of Akbarpur is situated on the bank of river Tons (Tamasa).

The Saryu river is the main river and is located at the northern boundary of the district. The Tanda block are located along this river and use its water for irrigation.

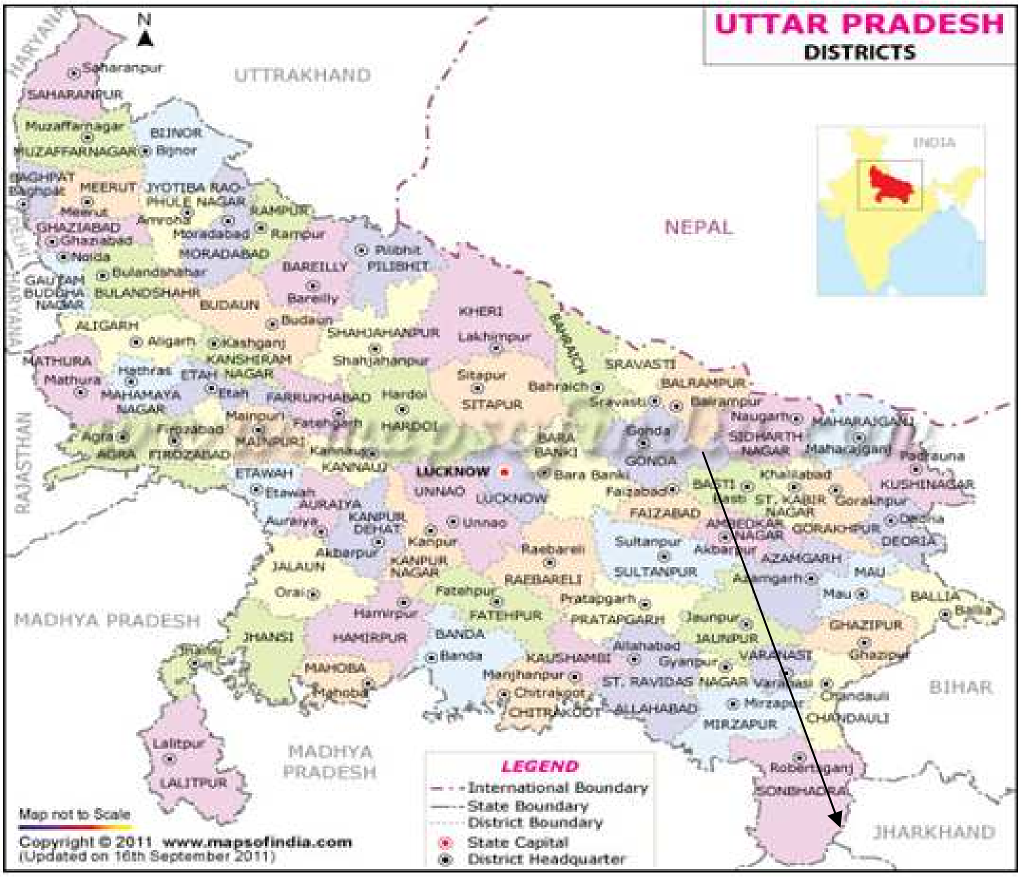

Figure 1: District Map of Uttar Pradesh

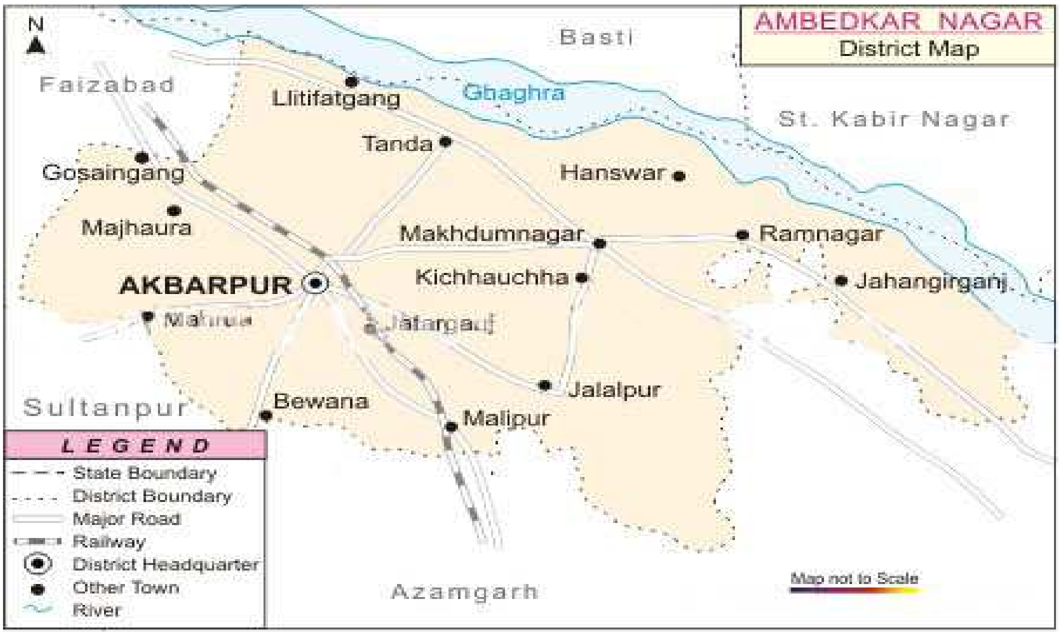

Figure 2: Geological map of Ambedkar Nagar District

METHODOLOGY

Estimation of Recurrence Rainfall

$$T = \frac{(N+1)}{m}$$

Estimation of Percentage Probability

$$P = \frac{1x100}{T}$$

Statistical Parameters

Probability of Occurrence of Rainfall

$$X_t = \overline{X} + (Kx\sigma)$$

Comparison of three Rainfall Probability, Distribution Model

Test of Goodness of Fit

$$X^2 = \frac{\sum_{i=1}^{K}(Oi - Ei)^2}{Ei}$$

RESULTS AND CONCLUSIONS

The present study concluded that the data of 20 years obtained from Tanda Block in Ambedker Nagar, U.P. is sufficient to obtain one to seven consecutive days annual maximum rainfall. Tue data were analyzed for fitting one to sever, consecutive days annual maximum rainfall at different probability levels through various theoretical distributions ; Gamma , Log normal, Gumbel and Log pearsons type III .The most suitable probability function to represent the observed data may depend on rainfall pattern of the place . As the rainfall pattern varies place to place the most suitable distribution may also vary from place to place. From the present rainfall analysis of the study area, the following conclusions are drawn from the study: -

- The maximum rainfall at Ambedker Nagar (Tanda) region of U.P. state was 267.4 mm, 318.4 mm, 354.00 mm, 364.6 mm, 374.2 mm, 387 mm and 418.2 mm for one, two, three, four, five, six and seven consecutive days annual maximum rainfall respectively.
- The statistical comparison at 9.52%, 23.81%, 47.62 **%, and** 95.24 % by chi- square test for goodness of fit. It clearly indicates that than the Gamma distribution was found to be best model for predicting one consecutive day’s annual maximum rainfall (mm).
- Gumbel distribution was showing very near to the observed rainfall for two and four consecutive day’s annual maximum rainfall (mm).
- Log Normal distribution was found to be best model for predicting third and sixth consecutive day’s annual maximum rainfall.

- Log Pearson type III shows best prediction for the five and seven consecutive day's annual maximum rainfall (mm)

Table 1: 1 to 7 Consecutive Days Annual Maximum Rainfall (Mm) at Different Returns Period in Years (1993-2012)

Years	1st Days Rainfall (mm)	2nd Days Rainfall (mm)	3rd Days Rainfall (mm)	4th Days Rainfall (mm)	5th Days Rainfall (mm)	6th Days Rainfall (mm)	7th Days Rainfall (mm)	Probability P (%)	Recurrence Interval (T)
2010	267.4	318.4	354	364.6	374.2	387	418.2	4.76	21.00
2004	148.2	237.6	290.6	341.6	371.4	377.8	409.8	9.52	10.50
2005	125.4	226.4	254.6	257.2	274.2	289.6	312.8	14.29	7.00
2007	116.4	205.4	241.8	247.4	273.6	286	298.6	19.05	5.25
1993	114.4	178.8	220.4	242.8	259	283.2	292	23.81	4.20
1998	113	160.6	201	236.4	255	268.2	291.6	28.57	3.50
2009	112.2	158.5	196.6	221	249.2	259.2	286	33.33	3.00
2011	109.6	147.2	185.8	215.6	239.6	243.2	268.2	38.10	2.63
2008	105.4	146	172.8	209.8	230.6	240	264.8	42.86	2.33
1994	101.4	145	174.6	201	214.2	239.6	261.4	47.62	2.10
2001	100.6	142.8	157	169.2	203.2	232.2	239.6	52.38	1.91
1997	98	140.6	146.6	160.8	187.8	195.4	202.8	57.14	1.75
2012	90	136.6	143.8	157.6	177.6	192.6	195.6	61.90	1.62
2003	86.8	129.6	139.8	150.8	162.8	173.4	192.6	66.67	1.50
1996	82	111	134.6	146.2	161.4	170.2	181.7	71.43	1.40
1999	67.4	102	128.8	143.8	154	164.2	175.2	76.19	1.31
1995	64	100.4	107	123.8	152.2	161.4	169.2	80.95	1.24
2006	62.6	82.6	105.2	112.8	112.8	134.4	140.8	85.71	1.17
2000	58.6	66.6	76	76	89.4	89.4	100.4	90.48	1.11
2002	46.6	66.2	69.8	71.8	71.8	73	87.8	95.24	1.05

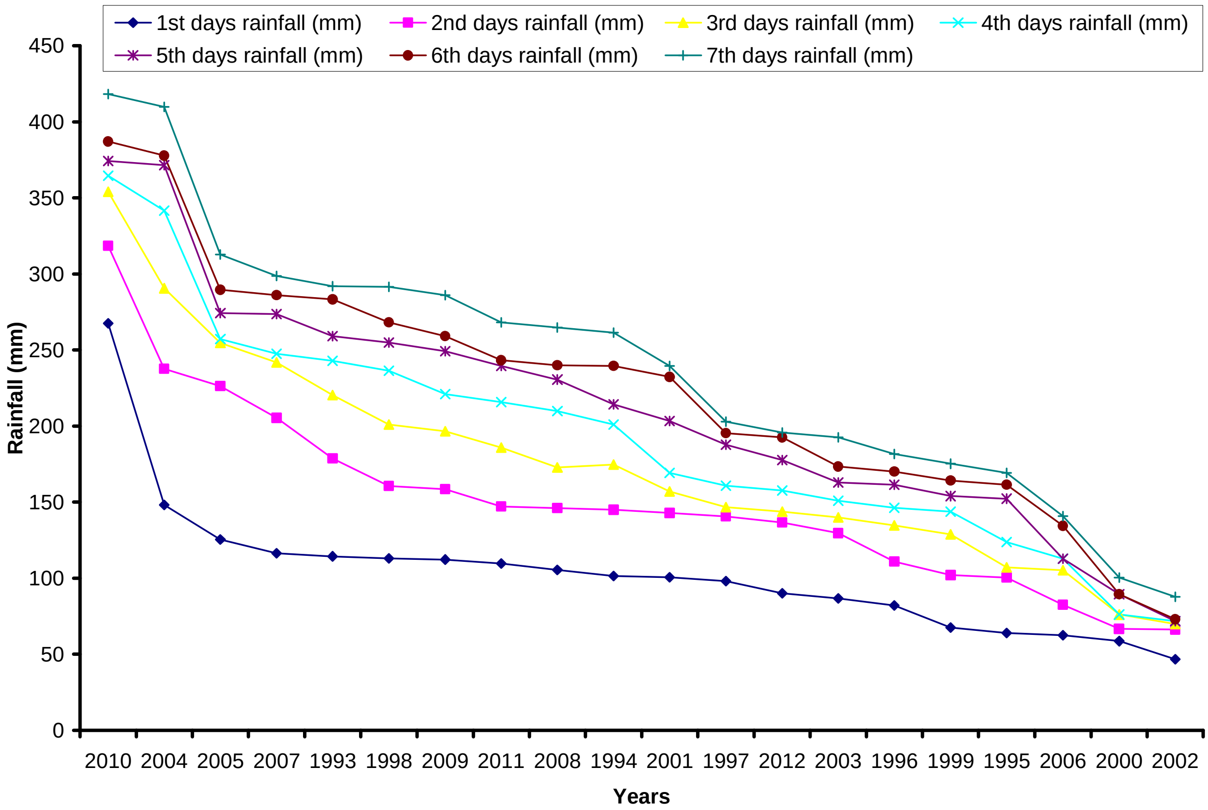

Figure 3: Comparison of Annual Rainfall at Different Days

Table 2: Chi Square Test of Goodness of Fit Various Distribution for 1 Days Annual Maximum Rainfall (mm)

Probability of exceedance (P) (%)	Return period (T)	Observed rainfall O (mm)	Estimated rainfall (E) mm for 1 day at different distribution levels				Chi square = $\Sigma(O-E)^2/E$			
			G	LP III	LN	GA	G	LP III	LN	Ga
95.24	1.05	46.60	82.84	102.15	122.58	102.23	15.857	30.206	47.100	30.272
47.62	2.10	101.40	102.63	97.69	97.04	83.81	0.015	0.141	0.196	3.692
23.81	4.20	114.40	104.62	103.30	101.42	100.65	0.913	1.192	1.662	1.880
9.52	10.50	148.20	120.13	116.46	111.49	102.13	6.557	8.652	12.087	20.778
Total							**23.34**	**40.19**	**61.05**	**56.62**

Table 3 Chi Square Test of Goodness of Fit Various Distribution for 2 Days Annual Maximum Rainfall (mm)

Probability of exceedance (P) (%)	Return period (T)	Observed rainfall O (mm)	Estimated rainfall (E) mm for 1 day at different distribution levels				Chi square = $\Sigma (O-E)^2/E$			
			G	LP III	LN	GA	G	LP III	LN	Ga
95.24	1.05	66.20	124.85	154.36	187.92	156.50	27.553	50.351	78.844	52.105
47.62	2.10	145.00	156.67	143.44	143.16	153.88	0.870	0.017	0.024	0.512
23.81	4.20	178.80	160.58	158.05	154.56	155.26	2.067	2.724	3.801	3.570
9.52	10.50	237.60	187.88	180.29	171.51	156.45	13.161	18.221	25.470	42.087
Total							**43.65**	**71.31**	**108.14**	**98.27**

Table 4: Chi Square Test of Goodness of Fit Various Distribution for 3 Days Annual Maximum Rainfall (mm)

Probability of Exceedance (P) (%)	Return Period (T)	Observed Rainfall O (mm)	Estimated Rainfall (E) mm for 1 day at Different Distribution Levels				Chi Square = Σ (O-E)^2/ E			
			G	LP III	LN	GA	G	LP III	LN	Ga
95.24	1.05	69.80	146.78	183.72	230.06	188.49	40.376	70.643	111.641	74.734
47.62	2.10	174.60	188.58	170.56	169.84	185.81	1.036	0.096	0.134	0.676
23.81	4.20	220.40	194.15	189.98	184.95	187.48	3.548	4.871	6.797	5.782
9.52	10.50	290.60	227.90	215.92	204.63	188.42	17.247	25.826	36.115	55.406
Total							**62.21**	**101.44**	**154.69**	**136.60**

Table 5: Chi Square Test of Goodness of Fit Various Distribution for 4 Days Annual Maximum Rainfall (mm)

Probability of exceedance (P) (%)	Return Period (T)	Observed rainfall O (mm)	Estimated Rainfall (E) mm for 1 Day at Different Distribution Levels				Chi Square = Σ (O-E)^2/ E			
			G	LP III	LN	GA	G	LP III	LN	Ga
95.24	1.05	71.80	163.95	206.20	263.49	213.95	51.792	87.600	139.455	94.450
47.62	2.10	201.00	214.05	192.80	191.36	210.60	0.795	0.349	0.486	0.438
23.81	4.20	242.80	219.09	210.43	205.05	212.57	2.566	4.981	6.950	4.298
9.52	10.50	341.60	263.16	246.46	232.33	213.91	23.379	36.729	51.393	76.217
Total							**78.53**	**129.66**	**198.28**	**175.40**

Table 6: Chi Square Test of Goodness of Fit Various Distribution for 5 Days Annual Maximum Rainfall (mm)

Probability of exceedance (P) (%)	Return Period (T)	Observed Rainfall O (mm)	Estimated Rainfall (E) mm for 1 Day at Different Distribution Levels				Chi Square = Σ (O-E)^2/ E			
			G	LP III	LN	GA	G	LP III	LN	Ga
95.24	1.05	71.80	173.52	218.66	283.25	228.77	59.628	98.640	157.855	107.701
47.62	2.10	214.20	228.82	204.29	202.55	225.57	0.934	0.481	0.670	0.573
23.81	4.20	259.00	234.13	223.07	217.12	227.34	2.643	5.788	8.076	4.408
9.52	10.50	371.40	283.72	263.58	247.73	228.73	27.097	44.106	61.737	88.989
Total							**90.30**	**149.01**	**228.34**	**201.67**

Table 7: Chi square Test of Goodness of Fit Various Distribution for 6 Days Annual Maximum Rainfall (mm)

Probability of Exceedance (P) (%)	Return Period (T)	Observed Rainfall O (mm)	Estimated Rainfall (E) mm for 1 Day at Different Distribution Levels				Chi Square = Σ (O-E)^2/ E			
			G	LP III	LN	GA	G	LP III	LN	Ga
95.24	1.05	73.00	183.19	232.96	305.07	243.07	66.279	109.835	176.538	118.996
47.62	2.10	239.60	243.33	222.07	219.04	228.71	0.057	1.384	1.930	0.519
23.81	4.20	283.20	250.09	239.94	232.85	242.00	4.384	7.800	10.885	7.015
9.52	10.50	377.80	294.99	274.19	258.75	242.98	23.249	39.153	54.777	74.800
Total							**93.97**	**158.17**	**244.13**	**201.33**

Table 8: Chi Square Test of Goodness of Fit Various Distribution for 7 Days Annual Maximum Rainfall (mm)

Probability of exceedance (P) (%)	Return period (T)	Observed rainfall O (mm)	Estimated rainfall (E) mm for 1 day at different distribution levels				Chi square = Σ (O-E)^2/ E			
			G	LP III	LN	GA	G	LP III	LN	Ga
95.24	1.05	87.80	200.93	253.95	325.05	262.41	63.697	108.710	173.168	116.183
47.62	2.10	261.40	262.72	243.42	240.31	218.10	0.007	1.327	1.851	8.597
23.81	4.20	292.00	267.67	256.22	250.24	260.69	2.212	4.995	6.969	3.761
9.52	10.50	409.80	319.19	299.75	283.27	262.34	25.720	40.401	56.514	82.886
Total							**91.64**	**155.43**	**238.50**	**211.43**

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